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(54) Improvements relating to distance measuring devices

(57) A radio frequency signal (microwave, laser or infra-red) is transmitted through a transducer 8 of a transmitting unit 1 and is received by a transducer 9 of a remote receiving unit 2. The incoming signal is analysed by the unit 10 and triggers a signal generator 11 to cause a sonic or ultrasonic signal to be transmitted through the transducer 9 back to the transmitting unit 1. The return signal is analysed by a circuit 12 which calculates the time lapse between transmission of the original RF signal and receipt of the return sound signal and calculates the distance between the units 1 and 2 and displays this information on a display device 13. (The time for transmission of the RF signal between units 1 and 2 is ignored). Temperature compensation is provided.

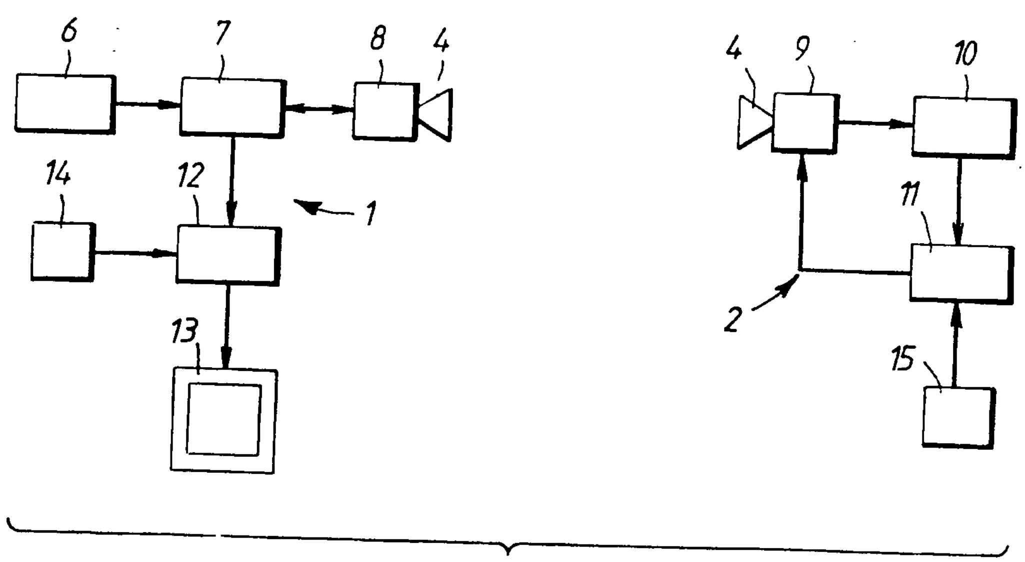

FIG. 2.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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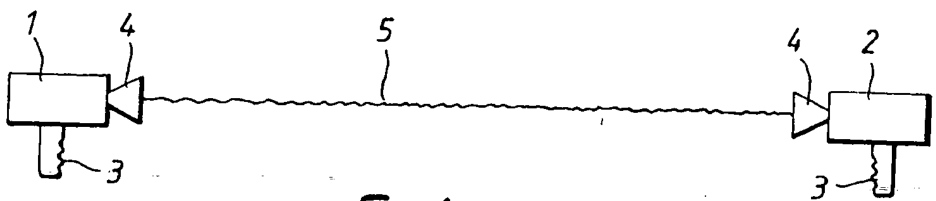

FIG. 1.

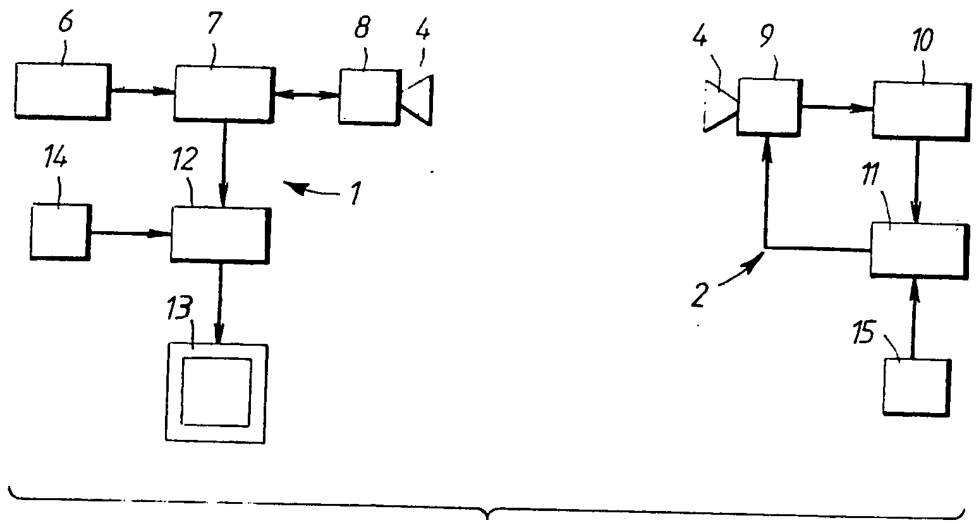

FIG. 2.

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SPECIFICATION

Improvements relating to distance measuring devices

This invention relates to devices for measuring distances with great accuracy, such as for surveying purposes. Often there is a need to measure the distance between two points when the prevailing conditions make it extremely difficult, if not impossible, to position a physical measuring device, such as a tape, between the two points.

It is an object of this invention to provide a distance measuring device which can measure the distance between the two points with great accuracy and reliability and which does not require the positioning of a physical member across the gap between the two points.

Accordingly this invention provides a distance measuring assembly comprising a transmitting unit and a receiving unit, wherein the transmitting unit is provided with control circuitry designed to transmit a signal at a predetermined first frequency and the receiving unit is provided with circuitry to analyse signals received from the transmitting unit and to cause a signal at a second frequency to be transmitted to the transmitting unit, upon receipt by the receiving unit of said first frequency signal, the transmitting unit or a third unit also incorporating a signal analysing unit to register receipt of the second frequency signal from the receiving unit, one of the signals being at a frequency which travels at the speed of light and the other signal being at a frequency which travels at the speed of sound, and a timing circuit to calculate the time interval between transmission of the first frequency signal and receipt of the second frequency signal and to calculate the distance between the transmitting and receiving units as a function of time and display information relating to the distance measured.

The use of signals at the two different frequencies ensures that there is no possibility of either the transmitting unit or the receiving unit responding inadvertently to a signal which it has produced itself. Also it is much easier to measure the travel time of signals travelling at the speed of sound than those travelling at the speed of light so that very accurate measurement of the distance can be made. The two frequency signals used during operation of the assembly can be chosen from a variety of types of signal, such as infra-red, microwave, radio frequency and laser beam signals on the one hand and sonic and ultrasonic beam signals on the other hand.

As a modification of the system the receiving unit could transmit signals to a further receiving unit and/or a different transmitting unit (as the third unit) so that the distance along a path could be measured over the various stages of the path. By this means the total length of a tortuous path, or one where there is no direct line of sight between the two ends, could be measured.

The frequency signals transmitted can act as carriers for other information. Thus, for example, the transmitting and receiving units could incorporate radio telephone circuitry so that spoken messages could be passed between the two units whilst distance measuring is being carried out. The circuitry for one or both units could additionally incorporate a temperature sensing device and temperature compensation means and information of the temperature conditions in the region of both units could be transmitted between the units. It is important to know the temperature of the air through which the transmitted signals are passing because the speed of sound in particular varies significantly with temperature. It is also proposed that the circuitry should incorporate means for determining a thermal image of the temperature conditions over the whole of the path between the two units so that even greater temperature compensation adjustment can be achieved.

For situations where it is important that the signal should be transmitted along a line of sight between the two units, a lens or horn may be mounted adjacent to the transducers which transmit and receive the signals to ensure that a very tight sonic or ultrasonic beam is transmitted between the two units. The transmission angle could be as small as 3° from the beam axis, but for other purposes could be as great as 45° from the beam axis.

The invention may be performed in various ways and a preferred embodiment thereof will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates transmitting and receiving units of a distance measuring assembly of this invention; and

Figure 2 is a block circuit diagram of the essential parts of the circuits for the two units shown in Figure 1.

The equipment shown in the drawings comprises a transmitting unit (or master unit) 1 and a receiving unit (or slave unit) 2, each of which is held by a handle 3 and carries a sound horn 4. Signals, diagrammatically illustrated at 5 are transmitted between the units 1 and 2.

The circuitry for the transmitting unit 1, as shown in Figure 2, comprises a control unit 6 which triggers operation of a signal generator 7 to cause a radio frequency signal to be transmitted through a transducer 8. This signal is received by a transducer 9 of the receiving unit 2 and the signal is analysed by an analysing unit 10. If the analysing unit 10 recognises a signal as being of a type which is expected to be received from the transmitting unit 1 it will trigger a signal generator 11 to cause a sonic or ultrasonic signal to be transmitted by means of the transducer 9 through the sound

horn 4. This sonic or ultrasonic signal is received by the sound horn 4 of the transmitting unit 1 and the received signal is analysed by a signal analysing circuit 12 which calculates the time between transmission of the original signal from the signal generator 7 and receipt of the received signal transmitted by the signal generator 11 and makes a calculation of the distance which must have been travelled by the signal passing between the receiving unit 2 and the transmitting unit 1. Information relating to this distance is illustrated on a display device 13.

Both the transmitting unit 1 and the receiving unit 2 incorporate a temperature sensor 14,15 respectively, each of which evaluates the temperature conditions in the region of the respective unit 1 or 2. This information is fed to the signal analysing circuits 12 and 10. Information relating to the temperature conditions in the region of the receiving unit 2 are transmitted on the return signal to the transmitting unit 1 acting as a carrier wave and the temperature conditions as recorded by the temperature sensing units 14 and 15 are taken into account by the signal analysing circuit 12 so as to make suitable adjustments to the distance calculation to allow for changes in the speed of sound through air as a function of a change in temperature. The signal generator 7 and signal analysing circuit 12 of the transmitting unit 1 will also incorporate means for evaluating the temperature conditions over the whole of the path travelled by signals between the units 1 and 2 so that an even more accurate adjustment for temperature effects can be made in calculating the distance between the two units 1 and 2.

A particular example of operation of the equipment is as follows. Units 1 and 2 are set at a distance of approximately 50 metres. The master unit 1 is switched on and after a 100 m/s delay (to allow for stability) a burst of RF at 27 mhzs is transmitted for one micro second and at the same time a temperature compensated oscillator is started. The slave unit 2 has a superheterodyne receiver built into the circuit. The realtime time lapse from the transmission to the receiving of the RF signal is insignificant. With the incorporation of the special circuitry, the trailing edges of the burst are used to overcome rise time and detection delays.

When the trailing edge of the RF burst is detected the slave unit 2 generates two waveforms namely a 0.8 m/s burst of 40.3 khz and a 0.4096 sec inhibit pulse. The 0.8 m/s burst is transmitted to the master unit 1 by an ultrasonic transducer at maximum power. The inhibit pulse is fed to the input circuit to disable the system for a preset time as a safety feature, the next burst of RF occurring in 0.4096 + 0.0004 secs.

The master unit 1 also consists of an ultrasonic receiver connected to three stages of band pass amplification (40.3 khz) to overcome rise time delays. There is no need to make the amplifier time controlled because the ultrasonic signal is only going in the one direction and there is no need to differentiate between small or large objects. The signal is then used to stop a clock to enable a count proportional to distance to be displayed on the display device 13.

A very surprising feature of operation of the equipment has been discovered. This is that if the master and slave units are situated so that there is equipment, walls or other objects between them, the master unit will still provide a reading, upon operation, and the distance indicated is found to be very close to the shortest air path between the two units (i.e. passing round the corners of the intervening objects). This phenomenon operates at distances up to several 10's of metres. This method of operation would be of great use, for example, in determining the air path in a ventilation system or the length of a section of sewer pipe whose precise path is unknown.

It will be appreciated that the transmitting unit 1 could transmit sonic or ultrasonic signals whilst the receiving unit 2 would then transmit high frequency signals. Indeed the type of high frequency signal transmitted can be chosen from a great number of possibilities including, for example, infra-red, microwave and laser beams. The transmitted signals may be coded or act as carriers for coded information or as carriers for radio telephone signals between the two units 1 and 2.

Whilst the two units 1 and 2 are illustrated in Figure 1 as being identical, for many purposes it is envisaged that the "slave" unit 2 will be quite small in size and will incorporate just the necessary circuitry to enable it to receive and tránsmit the relevant signals. It could even be in the nature of a large button-like object which could be pinned to the lapel of someone assisting the user of the main unit 1. Either or both of the units could be designed for mounting on fixed supports if required. The equipment can be employed for a great variety of uses, particularly to assist architects and surveyors and in certain industrial applications.

CLAIMS

1. A distance measuring assembly comprising a transmitting unit and a receiving unit, wherein the transmitting unit is provided with control circuitry designed to transmit a signal at a predetermined first frequency and the receiving unit is provided with circuitry to analyse signals received from the transmitting unit and to cause a signal at a second frequency to be transmitted to the transmitting unit, upon receipt by the receiving unit of said first frequency signal, the transmitting unit or a third unit also incorporating a signal analysing unit to register receipt of the second fre-

quency signal from the receiving unit, one of the signals being at a frequency which travels at the speed of light and the other signal being at a frequency which travels at the speed of sound, and a timing circuit to calculate the time interval between transmission of the first frequency signal and receipt of the second frequency signal and to calculate the distance between the transmitting and receiving units as a function of time and display information relating to the distance measured.

2. An assembly according to claim 1, wherein one of the units is constructed to transmit infra-red, microwave radio frequency or laser beam signals and the other unit is constructed to transmit sonic or ultrasonic beam signals.

3. An assembly according to claim 1 or claim 2, including a further receiving and/or a different transmitting unit provided as the third unit to receive signals from the main receiving unit.

4. An assembly according to any one of claims 1 to 3, wherein the transmitting and receiving units incorporate circuitry enabling additional signals to be transmitted on the first or second frequency signals acting as a carrier wave.

5. An assembly according to any one of claims 1 to 4, wherein the circuitry for one or both units additionally incorporates a temperature sensing device and temperature compensation means.

6. An assembly according to any one of claims 1 to 5, wherein the circuitry for one or both units incorporates means for determining a thermal image of the temperature conditions over the whole of the path between the two units.

7. An assembly according to any one of claims 1 to 6, wherein the lens or horn is mounted adjacent to transducers which transmit and receive the signals.

8. An assembly according to claim 7, wherein the transmission angle for the lens or horn lies between 3° and 45° from the beam axis.

9. A distance measuring assembly substantially as herein described with reference to the accompanying drawings.

10. A method of measuring distances between two points using an assembly as defined in any one of claims 1 to 9, wherein the two units are set at a respective One of the two points, the first frequency signal is transmitted from the transmitting unit for receipt by the receiving unit to trigger the transmission of a signal at the second frequency from the receiving unit to the transmitting unit and the second frequency signal received by the transmitting unit is analysed to calculate the distance between the transmitting and receiving units.

11. A method of measuring the distance between two points substantially as herein described with reference to the accompanying drawings.

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